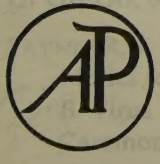
JOURNAL OF THEORETICAL BIOLOGY

Co-Chief Editors: S. A. KAUFFMAN
L. WOLPERT

Editorial Board:
N. BARTON
C. BLOMBERG
J. BONNER
A. CORNISH-BOWDEN
J. COWAN
J. A. DANI
F. DYSON
J. M. GELFAND
M. E. GILPIN
L. GLASS
A. GOLDBETER
B. GOODWIN
M. HASSALL
P. W. HEDRICK
T. B. L. KIRKWOOD
J. H. LEWIS
W. R. LIEB
R. B. LUFTIG
R. M. MAY
J. MAYNARD SMITH
J. D. MURRAY
T. OHTA
H. H. PATTEE
A. S. PERELSON
C. PESKIN
S. L. PIMM
J. RINZEL
M. R. ROSE
M. SAVAGEAU
P. SCHUSTER
T. TAKENAKA
J. TYSON
J. Z. YOUNG

VOLUME 159
November–December



ACADEMIC PRESS
London San Diego New York Boston
Sydney Tokyo Toronto

Copyright © 1993, by Academic Press Limited

ALL RIGHTS RESERVED

No part of this volume may be reproduced in any form, by photostat, microfilm, or any other means, without written permission from the publishers.

Printed in Great Britain

Contents for Volume 159

Number 1, 7 November 1992

VAN VEEN, M. and VAN PELT, J., A Model for Outgrowth of Branching Neurites 1

POLLOCK, G. and DUGATKIN, L. A., Reciprocity and the Emergence of Reputation 25

WOLD, M. P. and GAMOW, R. I., Fiber-composite Model for Helical Growth in the *Phycomyces* Cell Wall 39

SÝKORA, P., Macroevolution of Plasmids: A Model for Plasmid Speciation 53

BENHAMOU, S., Efficiency of Area-concentrated Searching Behaviour in a Continuous Patchy Environment 67

EXLEY, C. and BIRCHALL, J. D., The Cellular Toxicity of Aluminium . 83

SZATHMÁRY, E., Viral Sex, Levels of Selection, and the Origin of Life . 99

SEYMOUR, R. M. and BRADBURY, R. H., Is the Crown-of-thorns Starfish Degrading the Great Barrier Reef? 111

Number 2, 21 November 1992

VAN SOEST, P. J., FRANCE, J. AND SIDDONS, R. C., On the Steady-state Turnover of Compartments in the Ruminant Gastrointestinal Tract 135

THIEBAUX, M. L. AND DICKIE, L. M., Models of Aquatic Biomass Size Spectra and the Common Structure of their Solutions 147

PECK, J. R., Group Selection, Individual Selection, and the Evolution of Genetic Drift 163

DONCASTER, C. P. AND MACDONALD, D. W., Optimum Group Size for Defending Heterogenous Distributions of Resources: A Model Applied to Red Foxes, *Vulpes vulpes*, in Oxford City 189

DI GIULIO, M., On the Origin of the Transfer RNA Molecule . . . 199

PAYNE, R. J. H., NOWAK, M. A. AND BLUMBERG, B. S., Analysis of a Cellular Model to Account for the Natural History of Infection by the Hepatitis B Virus and its Role in the Development of Primary Hepatocellular Carcinoma 215

Goss, R. J., The Evolution of Regeneration: Adaptive or Inherent? . . 241

Helmstetter, C. E., Leonard, A. C. and Grimwade, J. E., Relationships between Chromosome Segregation, Cell Shape and Temperature in *Escherichia coli* 261

Letter to the Editor

Pollanen, M. S., Dimensional Optimization at Different Levels of the Arterial Hierarchy 267

Number 3, 7 December 1992

Lucas, M. L., Sood, L., McGregor, M., Sattar, N., Watt, A. and Taylor, J. C., The Effect of Auxiliary Conditions on Intestinal Unstirred Layer Diffusion Modelled by Numerical Simulation 271

Kunisawa, T., Synonymous Codon Preferences in Bacteriophage T4: A Distinctive Use of Transfer RNAs from T4 and from its Host *Escherichia coli* 287

Stückle, E. E., Nielsen, P. J. and Grob, U., Probability of Occurrence of Specific Oligomers 299

Saunders, K. B. and Cummin, A. R. C., Estimates of Mean Alveolar PCO_2 During Steady-state Exercise in Man: A Theoretical Study . . 307

Nowak, M. A. and May, R. M., Coexistence and Competition in HIV Infections 329

Morris, V. B., Spatial Patterns of Cells in Dividing Epithelia . . . 343

Bois, F. Y. and Compton-Quintana, P. J. E., Sensitivity Analysis of a New Model of Carcinogenesis 361

Letter to the Editor

Rubin, H. N. and Halim, M. N., Comparison of Translation in Eukaryotic Mode with Translation in Prokaryote Mode 377

Number 4, 21 December 1992

Quenette, P.-Y. and Gerard, J.-F., Does Frequency-dependent Selection Optimize Fitness? 381

Yi, T. and Songling, Z., Resource-dependent Selection 387

BECKERS, R., DENEUBOURG, J. L. and GOSS, S., Trails and U-turns in the Selection of a Path by the Ant *Lasius niger* 397

MAREK, J., A Difference in the Shapes of Intermolecular Potentials Between Phospholipid Model Molecules. Relation to the Ripple Phase . . 417

TORTOLERO, M. and MEDINA, J. R., Males and the Two-fold Disadvantage of Dioecy 431

MCMANUS, I. C. and BRYDEN, M. P., Handedness of Parents and Sex of Progeny: Failure to Replicate the Results of James (1986) 439

MÄKELÄ, A. and SIEVÄNEN, R., Height Growth Strategies in Open-grown Trees 443

SOLÉ, R. V., BASCOMPTE, J. and VALLS, J., Stability and Complexity of Spatially Extended Two-species Competition 469

DAY, W. H. E. and MCMORRIS, F. R., Threshold Consensus Methods for Molecular Sequences 481

LEWIS, J. E., GLASS, L., BACHOO, M. and POLOSA, C., Phase Resetting and Fixed-delay Stimulation of a Simple Model of Respiratory Rhythm Generation 491

DEXTER, F., YANG, T. and LEVY, M. N., Analysis of Vagally Induced Sinus Arrhythmias 507

LEONARD, J. L., The "Love-dart" in Helicid Snails: a Gift of Calcium or a Firm Commitment? 513

WILLS, P. R., Potential Pseudoknots in the PrP-encoding mRNA . . 523

MILLONAS, M. M., A Connectionist Type Model of Self-organized Foraging and Emergent Behavior in Ant Swarms 529

Index to Volume 158

Aluminium, cellular toxicity of, 83
Alveolar PCO_2 during steady-state exercise in man; estimates, a theoretical study, 307
Ant *Lasius niger*, trails and U-turns in the selection of a path by, 397
Ant swarms, a connectionist type model of self-organized foraging and emergent behavior in, 529
Aquatic biomass size spectra and the common structures of their solutions, models of, 147
Arrhythmias, sinus, vagally induced, analysis of, 507
Arterial hierarchy, dimensional optimization at different levels of (letter), 267

BACHOO, M. (see LEWIS, J. E.), 491
Bacteriophage T4, synonymous codon preferences; transfer RNAs from T4 and host, *E. coli*, 287
BASCOMPTE, J. (see SOLÉ, R. V.), 469
BECKERS, R., DENEUBOURG, J. L. and GOSS, S., Trails and U-turns in the selection of a path by the ant *Lasius niger*, 397
BENHAMOU, S., Efficiency of area-concentrated searching behaviour in a continuous patchy environment, 67
Biomass, aquatic, size spectra and the common structure of their solutions, models of, 147
BIRCHALL, J. D. (see EXLEY, C.), 83
BLUMBERG, B. S. (see PAYNE, R. J. H.), 215
BOIS, F. Y. and COMPTON-QUINTANA, P. J. E., Sensitivity analysis of a new model of carcinogenesis, 361
BRADBURY, R. H. (see SEYMOUR, R. M.), 111
Branching neurites, a model for outgrowth of, 1
BRYDEN, M. P. (see MCMANUS, I. C.), 439

Carcinogenesis, sensitivity analysis of a new model, 361
Carcinoma, hepatocellular, primary, development of, 215
Cells in dividing epithelia, spatial patterns of, 341
Cell shape, chromosome segregation and temperature in *Eschericha coli*, 261
Cellular model for natural history of infection by the hepatitis B virus, 215
Cellular toxicity of aluminium, 83
Chromosome segregation, cell shape and temperature in *Eschericha coli*, 261
Coexistence and competition in HIV infections, 329
Competition in HIV infections, 329
Competition, two-species, spatially extended, stability and complexity of, 469
Complexity and stability of spatially extended two-species competition, 469
COMPTON-QUINTANA, P. J. E. (see BOIS, F. Y.), 361
Crown-of-thorns starfish and degradation of the Great Barrier Reef, 111
CUMMIN, A. R. C. (see SAUNDERS, K. B.), 307
DAY, W. H. E. and MCMORRIS, F. R., Threshold consensus methods for molecular sequences, 481

DENEUBOURG, J. L. (see BECKERS, R.), 397
DEXTER, F., TIANEN, Y. and LEVY, M. N., Analysis of vagally induced sinus arrhythmias, 507
DICKIE, L. M. (see THIEBAUX, M. L.), 147

Diffusion: the effect of auxiliary conditions on intestinal unstirred layer diffusion modelled by numerical simulation, 271
DI GIULIO, M., On the origin of the transfer RNA molecule, 199
Dimensional optimization at different levels of the arterial hierarchy (letter), 267
Dioecy, males and the two-fold disadvantage of, 431
DONCASTER, C. P. and MACDONALD, D. W., Optimum group size for defending heterogenous distributions of resources: a model applied to red foxes, *Vulpes vulpes*, in Oxford City, 189
DUGATKIN, L. A. (see POLLOCK, G.), 25

Epithelia, dividing, spatial patterns of cells in, 343
Escherichia coli: chromosome segregation, cell shape and temperature, 261
Escherichia coli, use of transfer RNAs from T4 and from; synonymous codon preferences in bacteriophage T4, 287
Eukaryotic mode translation compared with prokaryote mode translation (letter), 377
Evolution of genetic drift; group and individual selection, 163
Evolution of regeneration: adaptive or inherent?, 241
Exercise, steady-state, in man, theoretical estimates of mean alveolar PCO_2 during, 307
EXLEY, C. and BIRCHALL, J. D., The cellular toxicity of aluminium, 83

Fitness optimization by frequency-dependent selection, 381
Foraging and emergent behaviour in any swarms; a connectionist type model, 529
Foxes, red, in Oxford City; optimum group size for defending heterogenous distributions of resources, 189
FRANCE, J. (see VAN SOEST, P. J.), 135
Frequency-dependent selection and optimization of fitness, 381

GAMOW, R. I. (see WOLD, M. P.), 39
Gastrointestinal tract, ruminant, the turnover of compartments in, 135
Genetic drift evolution; group and individual selection, 163
GERARD, J.-F. (see QUENETTE, P.-Y.), 381
GLASS, L. (see LEWIS, J. E.), 491
GOSS, R. J., The evolution of regeneration: adaptive or inherent?, 241
GOSS, S. (see BECKERS, R.), 397
Great Barrier Reef degradation and the crown-of-thorns starfish, 111
GRIMWADE, J. E. (see HELMSTETTER, C. E.), 261
GROB, U. (see STÜCKLE, E. E.), 299
Group selection, individual selection, and the evolution of genetic drift, 163
Group size, optimum, for defending heterogeneous distributions of resources; model applied to red foxes in Oxford City, 189
Growth, height, strategies in open-grown trees, 443

HALIM, M. N. (see RUBIN, H. N.), 377
Handedness of parents and sex of progeny: failure to replicate the results of James (1986), 439
Height growth strategies in open-grown trees, 443
HELMSTETTER, C. E., LEONARD, A. C. and GRIMWADE, J. E., Relationships between chromosome segregation, cell shape and temperature in *Escherichia coli*, 261
Hepatitis B virus, cellular model for natural history of infection by, 215
Hepatocellular carcinoma, primary, development of, 215
Hierarchy, arterial, dimensional optimization at different levels of (letter), 267
HIV infections, coexistence and competition in, 329

Intestinal unstirred layer diffusion modelled by numerical simulation, effect of auxiliary conditions on, 271

KUNISAWA, T., Synonymous codon preferences in bacteriophage T4: a distinctive use of transfer RNAs from T4 and form its host *Escherichia coli*, 287

Lasius niger, trails and U-turns in the selection of a path by, 397
LEONARD, A. C. (see HELMSTETTER, C. E.), 261
LEONARD, J. L., The "love-dart" in helicid snails: a gift of calcium or a firm commitment?, 513
LEVY, M. N. (see DEXTER, F.), 507
LEWIS, J. E., GLASS, L., BACHOO, M. and POLOSA, C., Phase resetting and fixed-delay stimulation of a simple model of respiratory rhythm generation, 491
Life, origin of, viral sex, and levels of selection, 99
"Love-dart" in helicid snails: a gift of calcium or a firm commitment?, 513
LUCAS, M. L., SOOD, L., MCGREGOR, M., SATTAR, N., WATT, A. and TAYLOR, J. C., The effect of auxiliary conditions on intestinal unstirred layer diffusion modelled by numerical simulation, 271

MACDONALD, D. W. (see DONCASTER, C. P.), 189
MCGREGOR, M. (see LUCAS, M. L.), 271
MCMANUS, I. C. and BRYDEN, M. P., Handedness of parents and sex of progeny: failure to replicate the results of James (1986), 439
MCMORRIS, F. R. (see DAY, W. H. E.), 481
Macroevolution of plasmids: a model for plasmid speciation, 53
MÄKELÄ, A. and SIEVÄNEN, R., Height growth strategies in open-grown trees, 443
Males and the two-fold disadvantage of dioecy, 431
MAREK, J., A difference in the shapes of intermolecular potentials between phospholipid model molecules. Relation to the ripple phase, 417
MAY, R. M. (see NOWAK, M. A.), 329
MEDINA, J. R. (see TORTOLERO, M.), 431
MILLONAS, M. M., A connectionist type of model of self-organized foraging and emergent behavior in ant swarms, 529
Molecular sequences, threshold consensus methods for, 481
Molecules, model, phospholipid, a difference in the shapes of intermolecular potentials between; relation to the ripple phase, 417
Molecule, transfer RNA, the origin of, 199
MORRIS, V. B., Spatial patterns of cells in dividing epithelia, 343
mRNA, PrP-encoding, potential pseudoknots in, 523

Neurites, branching, a model for outgrowth of, 1
NIELSEN, P. J. (see STÜCKLE, E. E.), 299
NOWAK, M. A. and MAY, R. M., Coexistence and competition in HIV infections, 329
NOWAK, M. A. (see PAYNE, R. J. H.), 215

Oligomers, specific, probability of occurrence of, 299
Outgrowth of branching neurites; a model, 1

Parental handedness and sex of progeny: failure to replicate the results of James (1986), 439
Patchy environment, efficiency of area-concentrated searching behaviour in, 67
Path selection by the ant *Lasius niger*, trails and U-turns in, 397
Patterns, spatial, of cells in dividing epithelia, 341
PAYNE, R. J. H., NOWAK, M. A. and BLUMBERG, B. S., analysis of a cellular model to account for the natural history of infection by the hepatitis B virus and its role in the development of primary hepatocellular carcinoma, 215
PCO_2, alveolar, during steady-state exercise in man; estimates, a theoretical study, 307

PECK, J. R., Group selection, individual selection, and the evolution of genetic drift, 163
Phospholipid model molecules, a difference in the shapes of intermolecular potentials between; relation to ripple phase, 417
Plasmid speciation model, 53
POLLANEN, M. S., Dimensional optimization at different levels of the arterial hierarchy (letter), 267
POLLOCK, G. and DUGATKIN, L. A., Reciprocity and the emergence of reputation, 25
POLOSA, C. (see LEWIS, J. E.), 491
Potentials, intermolecular, between phospholipid model molecules, a difference in the shapes of; relation to ripple phase, 417
Potential pseudoknots in the PrP-encoding mRNA, 523
Progeny, sex of, and handedness of parents; failure to replicate the results of James (1986), 439
Prokaryote mode translation compared with eukaryotic mode translation (letter), 377
PrP-encoding mRNA, potential pseudoknots in, 523
Pseudoknots, potential, in the PrP-encoding mRNA, 523

QUENETTE, P.-Y. and GERARD, J.-F., Does frequency-dependent selection optimize fitness?, 381

Reciprocity and the emergence of reputation, 25
Regeneration, evolution of; adaptive or inherent?, 241
Reputation, reciprocity and the emergence of, 25
Resource-dependent selection, 387
Resources, optimum group size for defending heterogenous distributions of; model applied to red foxes in Oxford City, 189
Respiratory rhythm generation, phase resetting and fixed-delay stimulation of a simple model, 491
Rhythm generation, respiratory; phase resetting and fixed-delay stimulation of a simple model, 491
RUBIN, H. N. and HALIM, M. N., Comparison of translation in eukaryotic mode with translation in prokaryote mode (letter), 377
Ruminant gastrointestinal tract, the steady-state turnover of compartments in, 135

SATTAR, N. (see LUCAS, M. L.), 271
SAUNDERS, K. B. and CUMMIN, A. R. C., Estimates of mean albeolar PCO_2 during steady-state exercise in man: a theoretical study, 307
Searching behaviour, area-concentrated, in a continuous patchy environment, efficiency of, 67
Selection, frequency-dependent, and fitness optimization, 381
Selection, group and individual, and the evolution of genetic drift, 163
Selection levels, viral sex, and the origin of life, 99
Selection, resource-dependent, 387
Sequences, molecular, threshold consensus methods for, 481
Sex of progeny and handedness of parents: failure to replicate the results of James (1986), 439
Sex, viral, levels of selection, and the origin of life, 99
SEYMOUR, R. M. and BRADBURY, R. H., Is the crown-of-thorns starfish degrading the Great Barrier Reef?, 111
Shapes of intermolecular potentials between phospholipid model molecules, difference in; relation to ripple phase, 417
SIDDONS, R. C. (see VAN SOEST, P. J.), 135
SIEVÄNEN, R. (see MÄKELÄ, A.), 443
Sinus arrhythmias, vagally induced, analysis of, 507
Size, group, optimum, for defending heterogeneous distributions of resources; model applied to red foxes in Oxford City, 189

Size spectra of aquatic biomass and the common structure of their solutions, models of, 147
Snails, helicid, the "love-dart" in; a goft of calcium or a firm commitment?, 513
SOLÉ, R. V., BASCOMPTE, J. and VALLS, J., Stability and complexity of spatially extended two-species competition, 469
SONGLING, Z. (see YI, T.), 387
SOOD, L. (see LUCAS, M. L.), 271
Spatial patterns of cells in dividing epithelia, 343
Spatially extended two-species competition, stability and complexity of, 469
Speciation, plasmid; a model, 53
Stability and complexity of spatially extended two-species competition, 469
Starfish, crown-of-thorns, and degradation of the Great Barrier Reef, 111
STÜCKLE, E. E., NIELSEN, P. J. and GROB, U., Probability of occurrence of specific oligomers, 299
Swarms, ant, a connectionist type model of self-organized foraging and emergent behavior in, 529
SÝKORA, P., Macroevolution of plasmids; a model for plasmid speciation, 53
Synonymous codon preferences in bacteriophage T4; transfer RNAs from T4 and from host *E. coli*, 287
SZATHMÁRY, E., Viral sex, levels of selection, and the origin of life, 99

TAYLOR, J. C. (see LUCAS, M. L.), 271
Temperature, chromosome segregation and cell shape in *Escherichia coli*, 261
THIEBAUX, M. L. and DICKIE, L. M., Models of aquatic biomass size spectra and the common structure of their solutions, 147
Threshold consensus methods for molecular sequences, 481
TIANEN, Y. (see DEXTER, F.), 507
TORTOLERO, M. and MEDINA, J. R., Males and the two-fold disadvantage of dioecy, 431
Toxicity, cellular, of aluminium, 83
Trails and U-turns in the selection of a path by the any *Lasius niger*, 397
Transfer RNA molecule, the origin of, 199
Transfer RNAs from T4 and from its host *E. coli*; synonymous codon preferences in bacteriophage T4, 287
Translation in eukaryotic mode compared with translation in prokaryote mode mode (letter), 377
Trees, open-grown, height growth strategies in, 443

Vagally induced sinus arrhythmias, analysis of, 507
VALLS, J. (see SOLÉ, R. V.), 469
VAN PELT, J. (see VAN VEEN, M.), 1
VAN SOEST, P. J., FRANCE, J. and SIDDONS, R. C., On the steady-state turnover of compartments in the ruminant gastrointestinal tract, 135
VAN VEEN, M. and VAN PELT, J., A model of outgrowth of branching neurites, 1
Viral sex, levels of selection, and the origin of life, 99
Vulpes vulpes in Oxford City; optimum group size for defending heterogenous distributions of resources, 189

WATT, A. (see LUCAS, M. L.), 271
WILLS, P. R., Potential pseudoknots in the PrP-encoding mRNA, 523
WOLD, M. P. and GAMOW, R. I., Fiber-composite model for helical growth in the *Phycomyces* cell wall, 39

YI, T. and SONGLING, Z., Resource-dependent selection, 387